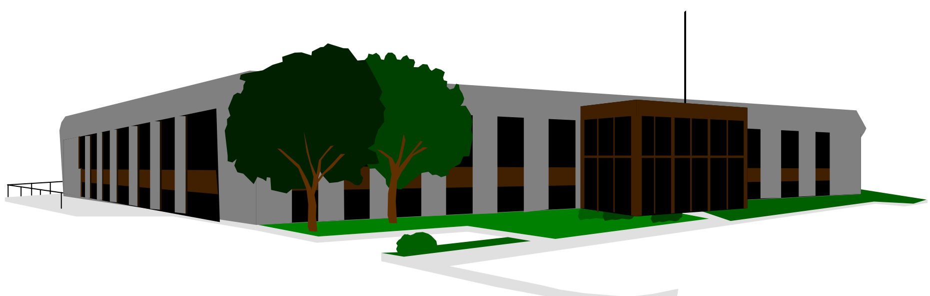
INDOOR AIR QUALITY ASSESSMENT

Thomas Passios Elementary School
1025 Massachusetts Avenue
Lunenburg, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
July, 2000

Background/Introduction

At the request of John Londa, Lunenburg School Department, the Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Thomas Passios Elementary School, 1025 Massachusetts Avenue, Lunenburg, Massachusetts. On April 4, 2000, a visit was made to this school by Mike Feeney, Chief of Emergency Response/Indoor Air Quality, BEHA. Mr. Feeney was accompanied by Mr. Londa.

The school is a single story structure reportedly built in 1953, with an addition in 1967. The building consists of three wings that contain general classrooms, main administrative office, library, cafeteria, art room, music room, learning center, and teacher's lounge. Windows are openable.

Methods

Air tests for carbon dioxide were taken with the Telaire Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the PTH Pen 8708 Thermo-hygrometer.

Results

This school has a student population of over 530 and a staff of approximately 30. The tests were taken during normal operations at the school. Test results appear in the Tables 1-3.

Discussion

Ventilation

Carbon dioxide levels were above 800 parts per million (ppm) in twenty-one out of twenty-nine classrooms surveyed, which is indicative of a ventilation problem in this school. Five classrooms with carbon dioxide levels below 800 ppm, either had open windows or no occupancy. Please note that classrooms 4, 6, 7, 8, 9, and 10 had carbon dioxide levels over 2,000 ppm, which indicates little if any airflow in these classrooms.

Ventilation in classrooms is provided by air handling units (AHUs) in each wing of the building. Fresh air intakes for AHUs are located on the roof (see Picture 1). These AHUs are connected by ductwork to fresh air diffusers located above the classroom hallway door. No airflow was detected from these fresh air diffusers, which indicates that the AHU system was either deactivated or blocked. A control switch located in a maintenance storeroom was activated, which in turn activated the AHUs. In order to provide fresh air to classrooms, the ventilation system must be activated while the building is occupied.

The cafeteria has unit ventilators (univents) that provide fresh air (see Picture 2). A univent draws fresh air from a vent on the exterior of the building and air from the room (called return air) through a vent in the base of its case (see Figure 1). Fresh air and return air are mixed, filtered, heated and expelled into the classroom through a fresh air diffuser located in the top portion of the case. A rolling refrigerator (see Picture 3) blocked the return vent of one univent. Fresh air supply and return vents must remain free of obstructions in order to function as designed.

The school has two different types of exhaust ventilation systems. In classrooms, exhaust ventilation is provided by ungrated holes connected to a ducted exhaust system (see Picture 4), which in turn are connected to the AHUs. Airflow is controlled by a flue, which is opened by a draw chain-pulley system (see Picture 5). The flue is set at a desired angle by setting the draw chain in a locking mechanism. These flues were found closed in a number of rooms surveyed. In addition, the vents were observed to be used for storage (see Picture 4 and 6). These vents need to be free of obstructions in order to function as designed.

The cafeteria has an exhaust system that has a vent covered with a fine mesh screen (see Picture 7). The surface of the porous sheet metal was heavily occluded by accumulated dust, reducing the ability of this vent to draw exhaust air from the cafeteria. The small diameter of the mesh tends to clog with ordinary dust, which inhibits airflow.

In order to have proper ventilation with a univent and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing of these systems could not be identified.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings recorded during the assessment were in a range of 70^{o}F to 74^{o}F, which is within BEHA's recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range between 70^{o}F to 78^{o}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 39 to 56 percent, which is very close to BEHA guidelines. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity measurements would be expected to drop during winter weather. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Mold and Mildew

A number of rooms had water-stained ceiling tiles, which are evidence of leaks from the roof. Each classroom has two types of ceiling tiles: one that is inserted into a suspended ceiling (see Picture 8), the other directly adhered to the ceiling. Classrooms originally had skylights (see Picture 9 for an example), which were sealed behind a suspended ceiling (see Picture 10). It appears that historical water leaks wet tiles throughout the building. This water damage appears heaviest around ceiling openings for the skylights. The source of this moisture may be cracks in skylight glass (see Picture 11). The school has a ceiling tile system that is glued directly to the ceiling. A number of classrooms have ceiling tiles that appear to be water-damaged. Replacement of the adhered ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile, which can result in the aerosolization of particulates. Water-damaged ceiling tiles may provide a medium for mold and mildew growth and should be replaced after a water leak is discovered and repaired.

Pooling water was noted on the roof, indicating poor drainage (see Picture 12). Pooling water was also noted on the cantilever roof on the exterior wall (see Picture

13). This roof has no support beneath it. The added weight of the water can increase tension, pulling this structure away from the building, and ultimately damaging the brickwork.

Water stained brick at the edge of the roof over the building's front door was evident (see Picture 14). The extent of this staining indicates long-term rainwater exposure of this brick. Water should be directed away from the exterior brick to prevent water penetration.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building (see Picture 15). Shrubbery can serve as a possible source of water impingement on the exterior curtain wall due to the location of plants growing directly against the building. Plants retain water and in some cases can work its way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. With this building under renovation, the introduction of particulates, gases and vapors can adversely effect indoor air quality in occupied areas of the school if not properly contained.

Of note is the prolific use of cleaning materials in this building (see Pictures 16). Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. Pesticides (see Picture 17), iodine (see Picture 18), restroom disinfectant (see Picture 19) and other materials were found in many classrooms. The use of these products can provide exposure opportunities for individuals to a number of chemicals, which can lead to irritation of the eyes, nose or respiratory tract. In all of these instances, cleaning products containing respiratory and skin irritants appear to be used throughout the building.

Classrooms have sinks, several of which are not in use (see Picture 20). This condition can lead to drain traps drying out, subsequently leading to sewer gas odors penetrating into the room through the unsealed trap. Sewer gas odors can be irritating to the eyes, nose and throat.

The filters in the AHU were not examined because of inaccessibility. AHUs are equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in the heat pumps. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40% would be sufficient to reduce airborne particulates (MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the heat pump by increased resistance. Prior to any increase of filtration, each heat pump should be evaluated by a ventilation engineer to ascertain whether the heat pump can maintain function with more efficient filters.

Conclusions/Recommendations

In view of the findings at the time of the inspection, the following recommendations are made:

1. Operate the AHUs during building occupancy.
2. Remove blockages from univent in cafeteria.
3. Examine air handlers throughout the school for function. Survey classrooms for air diffuser and exhaust vent function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
4. Remove stored materials from exhaust vents in classrooms. Ensure that the vent louver is in the open position in each exhaust vent.
5. Examine the filters in the AHUs and change these filters on a regular basis. Consider increasing the dust spot efficiency of filters to increase the removal of particulate from the environment.
6. Once fresh air supply and exhaust systems are functioning, the ventilation system needs to be balanced.
7. Water-damaged ceiling tiles should be replaced. These ceiling tiles can be a source of microbial growth and should be removed. The source of water leaks (e.g., broken skylight windows and roof leaks) should be identified and repaired. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.
8. Replace the wire mesh over the cafeteria exhaust vent with a louvered grille to increase draw of exhaust air.
9. Examine the feasibility of increasing drainage in areas of the roof prone to water pooling.

10. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning practices, to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low, should be implemented. Among these methods can be the use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance filter (HEPA). Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

11. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.

12. Seal abandoned drains or wet dry drain traps regularly to prevent odor migration into classrooms.

13. Reduce the use of cleaning materials that contain respiratory irritants (ammonia related compounds) on floors and in classrooms. Do not use these materials to disinfect equipment that comes into close contact with the respiratory system (e.g., telephones). Substitute plain soap and hot water for ammonia related cleaning products. Use of ammonia related cleaning products should only be where necessary. If ammonia containing cleaning products are used, rinse the area of application with water to remove residue.

14. Examine the feasibility of installing drainage for the cantilever roof in Picture 16.

15. Consider installing a rain gutter system on the low roof in Picture 17.

16. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F. (MGL. 1983

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

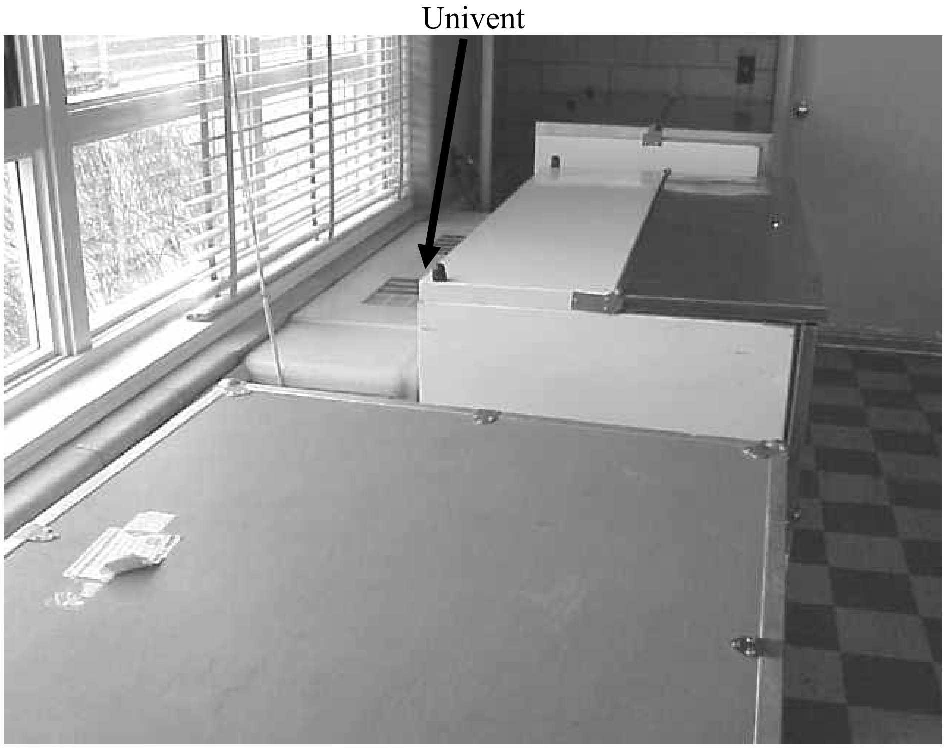
Picture 1

Fresh Air Intake on the Roof

Picture 2

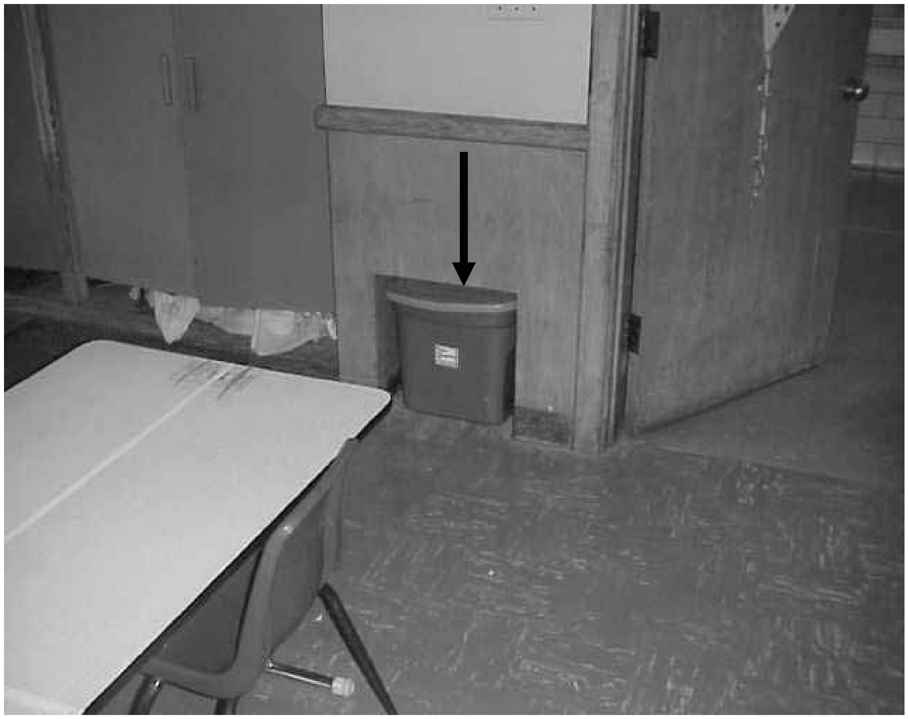
Cafeteria Univent

Picture 3



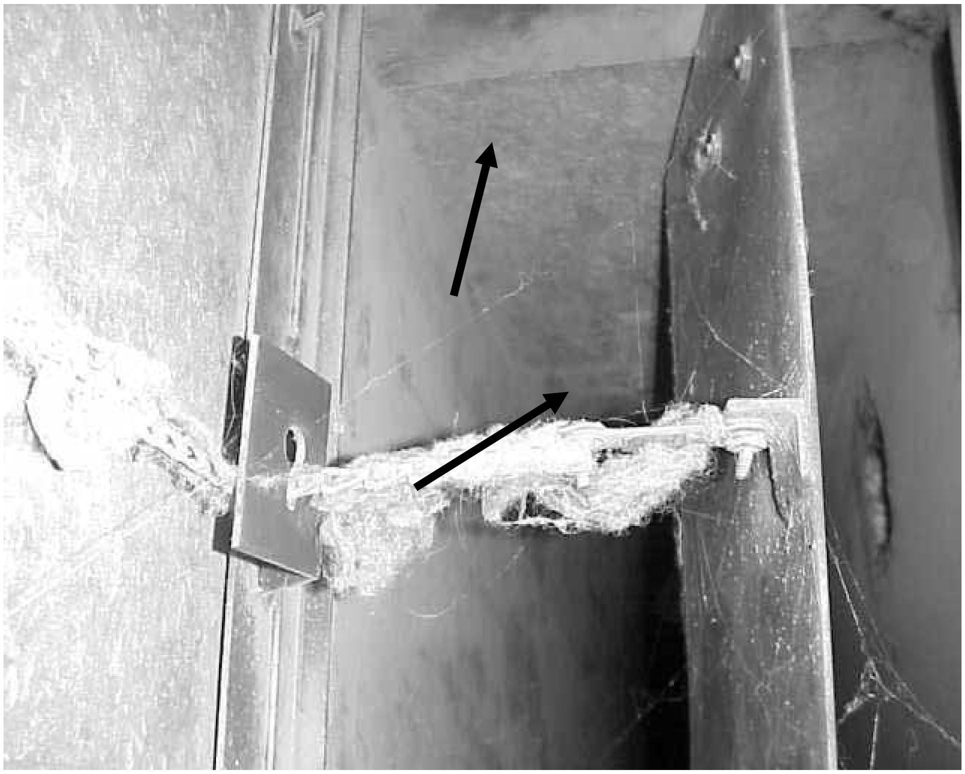
Cafeteria Univent Blocked by Rolling Refrigerator

Picture 4



Classroom Exhaust Vent

Picture 5



Exhaust Vent Louver and Pulley Control System

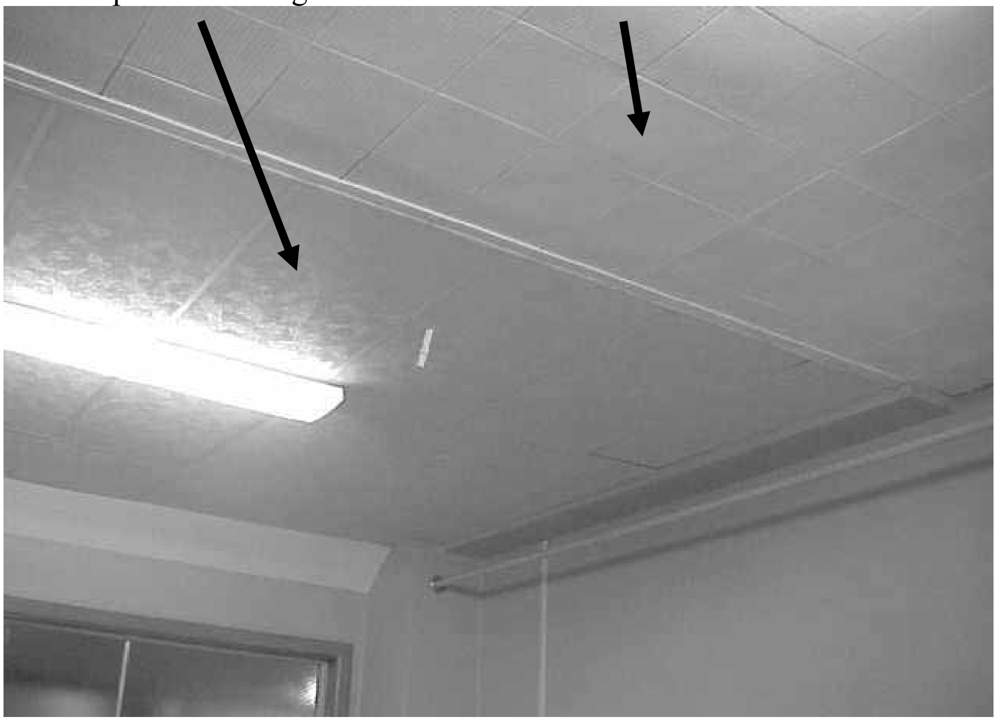
Picture 6

Exhaust Vent Blocked with Box

Picture 7

Fine Wire Mesh Covering Cafeteria Exhaust Vent

Picture 8



Suspended Ceiling Over Skylight and Tiles Adhered to Ceilings in Classrooms

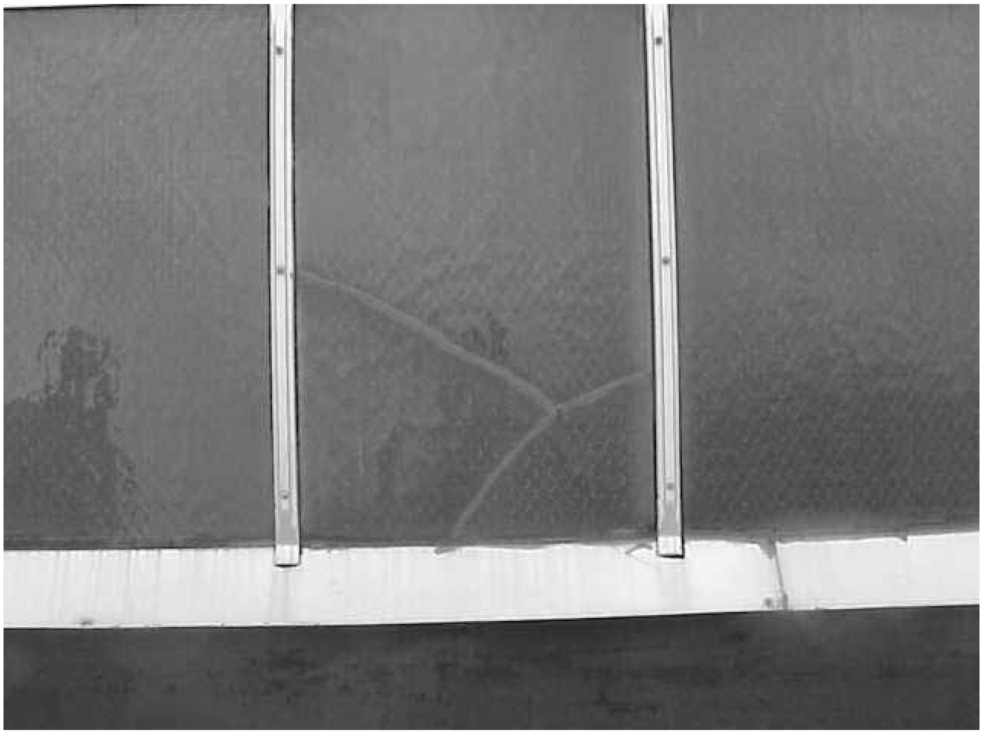
Picture 9

Example of Skylight Sealed in Classrooms

Picture 10

Skylight Sealed behind Suspended Ceiling

Picture 11



Cracked Skylight Glass

Picture 12

Pooling Water on Roof

Picture 13

Cantilever Roof with Pooled Water

Picture 14

Water Damaged Exterior Brick

Picture 15

Shrubbery Growing against the School Exterior Wall

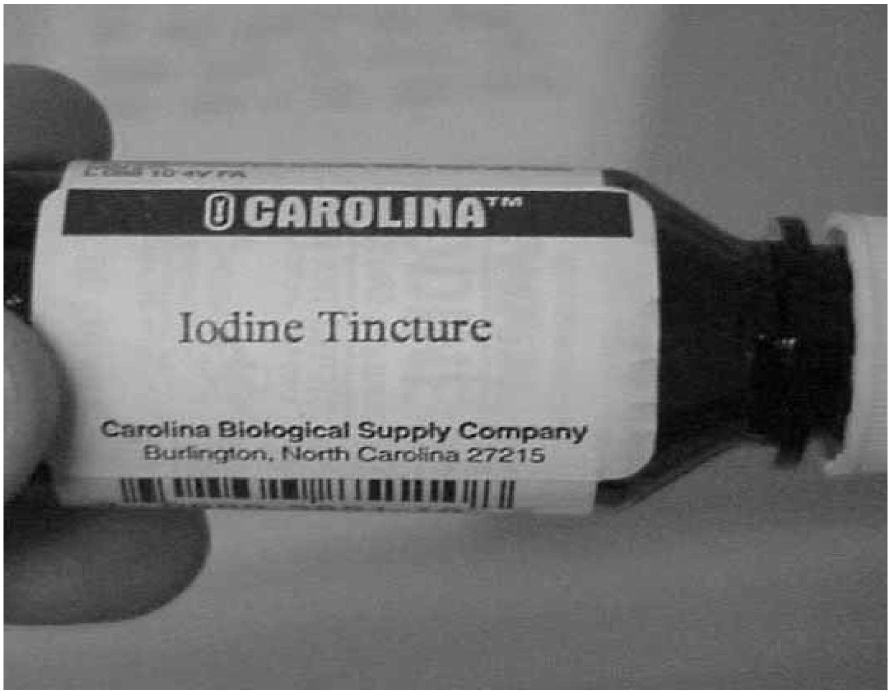
Picture 16

Cleaners Found in One Classroom

Picture 17

Pesticides Found in a Classroom

Picture 18



Iodine Tincture Found in a Classroom

Picture 19

Rest Room Disinfectant Found in Classrooms

Picture 20

Unused Sink in Classroom

TABLE 1

Indoor Air Test Results –Thomas Passios Elementary School, Lunenburg, MA – April 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	412	64	61					
Music Room	1170	73	44	25	yes	yes	yes	exhaust blocked by file cabinet, cleaners
Learning Center	1193	73	39	4	yes	yes	yes	20+ CT
Room 18	1381	73	51	24	yes	yes	yes	univent off-broken?, plants
Room 15	599	71	48	0	yes	yes	yes	univent off, window and door open
Room 16	770	73	47	0	yes	yes	yes	univent off, door open, 7 CT, cleaner
Room 13	571	72	47	0	yes	yes	yes	univent off, window and door open, cleaner
Room 14	1461	73	45	18	yes	yes	yes	univent off, door open, 10 CT, cleaners
Room 11	893	73	47	24	yes	yes	yes	univent off, exhaust blocked by boxes, window and door open, cleaners
Room 12	814	74	45	8	yes	yes	yes	univent off, exhaust blocked by waste basket
Room 1	1313	73	46	18	yes	yes	yes	door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Thomas Passios Elementary School, Lunenburg, MA – April 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Cafeteria	738	73	55	120+	yes	yes (3)	yes	univent blocked by refrigerator, accumulated dust in exhaust vent, ceiling fans
Gymnasium	1538	72	42	40+	no	yes	yes	supply and exhaust off
Room 24	701	73	50	45	yes	yes	yes	window and door open, dry erase board
Room 25	1388	74	46	26	yes	yes	yes	6 CT
Room 22	626	71	54	0	yes	yes	yes	window and door open, aquarium
Room 23	906	72	41	27	yes	yes	yes	exhaust flue closed, ammonia, door open
Room 21	971	72	46	22	yes	yes	yes	window open, cleaners
Library	899	72	47	25	no	yes	yes	2 CT, door open
Art Room 19	1261	73	46	16	yes	yes	yes	cleaners, door open
Main Office	1224	71	52	3	yes	no	no	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Thomas Passios Elementary School, Lunenburg, MA – April 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 8	2000+	70	46	1	yes	yes	yes	supply and exhaust off, door open
Room 10	2000+	70	56	28	yes	yes	yes	supply and exhaust off
Room 9	2000+	72	44	24	yes	yes	yes	supply and exhaust off, 6 CT, door open
Room 7	2000+	72	44	23	yes	yes	yes	supply and exhaust off
Room 6	2000+	72	49	15	yes	yes	yes	supply and exhaust off, 20+ CT, door open
Room 5	714	71	49	0	yes	yes	yes	supply and exhaust off, window open, dry erase board
Room 4	2000+	71	50	0	yes	yes	yes	supply off, 3 CT, door open
Room 3	738	72	53	0	yes	yes	yes	door open
Room 2	1108	72	47	4	yes	yes	yes	exhaust blocked by box, window open, 30+ CT

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%